A CYBERNETICS APPROACH
TO
MANAGEMENT ACCOUNTING

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INTRODUCTION

Management accounting as the function of assisting management in establishing plans, making decisions, and control is a purposive subsystem within a higher system--the organization. The subject matter of management accounting is information and the flow of information through and within the subsystems of the organization and with its external environment.

As the science of communication and control, cybernetics provides meaningful criteria and insights for assessing and analyzing the function of management accounting.

Adopting the rationale given by Stafford Beer for his concept "Management Cybernetics,"[1] we can make the following statements:

> For if cybernetics is the science of communication and control, and if the subject matter of management accounting might be described as the dissemination of information to assist management in doing its function, there ought to be a meaningful application of the fundamental cybernetics to the domain of management accounting.

The purpose of this paper is to discuss cybernetics in order to understand its development, features, characteristics, principles, and its tools of analysis. Thereby, we have some insight about its relevance and potential applications to the domain of management accounting.

FUNDAMENTALS OF CYBERNETICS

BACKGROUND AND OVERVIEW

Historically, cybernetics dates from the time of Plato who used the Greek word "kybernetic" to mean the art of steersmanship. The Latin word "gubernator" was derived from this Greek root basically to mean a political pilot. The English word "governor" was derived from the Latin word. It was not until James Watts in 1790 invented and termed his mechanical regulator a "governor" that the metamorphical sense gave way to the literal mechanical sense.[2]

Norbert Wiener was the first to coin the term "cybernetics" in 1947 to designate an area capable of universal application. In his words, cybernetics is "the science of control and communication in the animal and machine."[3] Stafford Beer defined cybernetics more broadly as the science of control and communication wherever these occur in whatever kinds of systems. That is to say that cybernetics studies the flow of information round a system, and the way in which that information is used by the system as a means of controlling itself.[4] Ross Ashby called it a theory of machine. However, it is essentially functional and behavioristic, because it deals not only with things but the way things behave.[5]

In his discussion of the relevance of cybernetics to organization, Beer clearly qualified the automation orientation of cybernetics. He pointed out that people often think that the relevance of cybernetics to organization has to do with automation, but this is not so because it can enhance the effectiveness of organization regardless of the degree to which advanced machines are in use.[6]

Cybernetics scope is not to be equated with electronic computers, automation, operations research, and a theory of machine. Its principles are applicable not only to engineering systems but also to living systems.[7]

In summary, cybernetics involves natural laws which govern and regulate the behavior of any type of systems in their growth, stability, learning, adopting, or evolving stages.

CYBERNETICS SYSTEMS AND GENERAL SYSTEM THEORY:

The core of cybernetics is the system[8]; once we understand the system with respect to its inputs, control and learning mechanisms, structure and functions, behavior, and its output, we can identify the cybernetic characteristics of the systems.

Before discussing the relationship between systems and cybernetics, we need to address the concept of systems and some of the developments in the General System Theory

(hereafter GST).

A. System:

There are various definitions of systems in the literature; one of the most clear and comprehensive definitions is given by Hall and Fagen as "a set of objects together with relationships between the objects and between their attributes connected or related to each other and to their environment in such a manner as to form an entirety or whole.[9]

Each of the elements of this definition needs a long discussion; however, we will just touch on some of them. System objects refer to the input(s), the process(es), the output(s), and the feedback control.

Relationship is very important. As Beer stated, a system is not something given in nature but something defined by intelligence. It is an act of mental recognition. In order to declare that a collection ought to be called a system, that is to say, we acknowledge relatedness.[10] The importance of relationships is expressed also by Heg l's axiom of "Internal Relationship" which entails that things would not be the things that they are if they were not related to everything else in the way that they are.[11] Relationships may take different modes such as symbiotic (unipolar or bipolar), synergistic, or/and redundant relationships.[12]

There is an obvious hierarchy of systems (the ultimate system being the universe). Any system can be divided and subdivided into subsystems and subsubsystems depending upon the particular level of relationship desired.

With respect to environment, a system may be a closed system where all of the system's resources are present at one time and there is no further influx of additional resources across the system's boundaries from the environment (i.e. heat system) or an open system where additional supplies of energy or resources can enter the system across its boundaries (i.e. human or organization).

It is also important to consider the system's behavior which refers to "a series of changes in one or more structural properties of the system or of its environment.[13] The movement path from one state to another represents the behavior of the system. Dynamic systems exhibit behavior (multistate), whereas static systems do not exhibit any behavior (one-state systems).[14]

B. General System Theory:

The General System Theory is concerned with developing a systematic theoretical framework for describing general relationships of the empirical. An ultimate but distant goal will be a framework (or system of systems of systems) which will tie all disciplines together in a meaningful relationship.[15]

World War II marked the end of an era of the machine age "Analytical Approach" and the beginning of a new era "System Age".[16] The shift into the system age stresses a point of view that a system is a whole that cannot be taken apart without missing some of its essential features. Therefore, instead of explaining a whole in terms of its parts, parts began to be explained in terms of the whole.

The realization of the importance of the holistic approach and the mutual interaction of the parts, and the emphasis on the nature of the problems in different disciplines rather than their form, prove that humans and organisms cannot be understood without studying their environment, and the realization of the nature and impact of complex organization led to the movement toward the GST.

Although the idea of GST has been developed and employed throughout history, it remained for Ludwig von Bertalanffy to formalize and advocate this idea in the 1920's.[17]

Bertalanffy based his idea on the Aristotelian philosophy that viewed objects as a whole and as endowed with intrinsic goals (telos). He defines system as "a dynamic order of parts and processes standing in mutual interaction."[18] For him, all living systems are open system.

Boulding tried to develop a realistic viewpoint for structuring and integrating the various separate disciplines

while retaining the characteristic of discipline which distinguishes them. In doing so, he discussed two approaches which provide a general framework. The first one is to pick out phenomena common to many different disciplines and to develop a general model which would include such phenomena. The second approach is to structure a hierarchy of levels of complexity for the basic units of behavior in the various empirical fields and to develop a level of abstraction to represent each stage.[19] The latter approach is of great interest because it presents a nine ordering of systems on the basis of their degree of complexity as a way to study them.

In 1954, a Society for General System Theory (GST), later called Society for General Systems Research, was founded at the annual meeting of the American Association for Advancement of Science (AAAS) under the leadership of biologist Bertalanffy, economist Boulding, biomathmatician Rapoport, and physiologist Gerard. Its purposes were to:

1. Investigate the isomorphy of concepts, laws, and models in various fields, and to help in useful transfers from one field to another;
2. Encourage the development of adequate theoretical models in the fields which lack them;
3. Minimize the duplication of theoretical effort in

different fields; and

4. Promote the unity of science through improving communication among specialists.[20]

C. Characteristics of Cybernetics Systems:

Stafford Beer discussed three characteristics for a system in order to be a cybernetics system; they are exceedingly complex, probabilistic, and self-regulated.[21]

Complexity is a relative concept which is determined by the interaction of various quantitative and nonquantitative factors. Schoderbek and others suggested the following four determinants to detect the degree of complexity:

1. The number of elements comprising the system;
2. The attributes of the specified elements of the system;
3. The number of interactions among the specified elements of the system; and
4. The degree of organization inherent in the system.[22]

As we can see, determinants one and three are quantitative ones and are mostly being used in measuring complexity. Using these two determinants, Beer statistically measured complexity in terms of the probability of a system's being in a specific state at a given time. Variety, in his opinion, as a measure of complexity is a function of the number of distinguishable elements and the probability of

the state of nature of the relationships among these elements.[23]

Beer's measurement of complexity is not comprehensive since it ignores the qualitative determinants 2 and 4 above, the interaction between the system and its environments, and the capability of the person who deals with the systems and the instruments involved in the analysis.

The following figure depicts a classification of systems which explain the interactions among the factors which characterized the cybernetics systems.

Figure (1)

Complexity / Predictability	Simple	Complex	Exceedingly Complex
Deterministic (one state of nature)	Pulley Typewriter Calculator	Computer Planetary system	Empty Set
Type of control required	Control of inputs	Control of inputs	Control of inputs
Probabilistic (Many states of nature)	Quality control Games of chance Machine breakdown	Sales Inventory levels All conditional behavior	Firm Human Economy
Type of control required	Statistical	Operations research	Cybernetics

Adapted from: Charles G. Schoderbek, et al., Management System, op. cit., p. 60.

We can see from the above Figure (1) meaningful and insightful understanding of cybernetics systems which results from adopting a comprehensive view of complexity. We can also see that cybernetics will come into play with the probabilistic and exceedingly complex systems.

The first group in Figure (1) are deterministic systems which contemplate a set of predetermined behavior. For instance, if we take a calculator which performs basic mathematical functions, the resulting output can always be predicted. Some other examples of these types of systems are typewriters, billiards, and most of the machines operated in the organization. Therefore, in deterministic systems the outputs can be predicted by controlling the inputs.

Moving from simple deterministic systems to complex deterministic ones, the degree of complexity increases. Computers can be viewed as more complex calculators which not only perform basic mathematical operations but also are capable of making comparison, and it is considered to be self-organized in doing its internal operations. However, computer stops far from being a consciousness since it will choose one alternative out of the various alternatives based on given conditions. It should be emphasized that the behavior of these types of systems are predetermined and only one state of nature exists in these

types of systems. The type of control required would be the same as in simple deterministic systems, that is, input control.

Adding another possible state of nature, we will have a probabilistic system. In a simple probabilistic system, the human elements are introduced. For example, in quality control, introducing the human elements and human beings usually show many states of behavior. Because of the existence of many states of nature in these types of systems, the quality becomes a variable factor. In order to ensure that a certain state of nature will always prevail, the quality control techniques are utilized in this case. Prediction and control of the system's behavior become extremely difficult and a function of the number of states of nature which the system exhibits.

The last category in Figure (1) includes probabilistic and extremely complex systems. The examples of these types of systems are organizations, firms, human beings, and economic systems which exhibit many variable states of nature.[24] Organizations and firms which are made up of many subsystems interact with each other and with their environment in obtaining their goals and the overall goal of the system. Since these types of systems exhibit many states of nature, most traditional types of control are ineffective in dealing with these types of exceedingly

complex systems. Thus, cybernetics is the relevant type of control in these circumstances.

Self-regulatory feature as a third characteristic in Beer's analysis refers to the notion of intrinsic control or of self-regulation as distinguished from mere regulation.[25] In other words, control from within using the principle of error-controlled negative feedback as an essential device to bring back the system to its state of equilibrium through the act of going out of control.

D. Analytical Tools of Cybernetic Systems:

For each of the three characteristics of cybernetic systems, Schoderbek discussed specialized tools for defining, operating, and controlling the cybernetic systems.[26] Figure (2) summarizes the characteristics of cybernetic systems and the appropriate tool of analysis.

Figure (2)

Characteristics of a Cybernetics System	Tools for Analysis
Exceeding Complexity	Black Box and Ashby's Law
Probabilism	Information Theory
Self-regulation	Feedback Mechanism

Adapted from: Charles G. Schoderbek, et al., op. cit., p. 62.

In Summary, detailed analysis will be presented later in the section of application to managerial accounting. Cybernetics as the science of control and communication is

applicable to highly complex phenomena, especially those which do not readily lend themselves to traditional analytical tools. Black box technique and the implications of the law of requisite variety are the most perfect techniques to deal with the extremely complex systems. Information theory is the relevant tool to deal with undeterministic systems which exhibit different states of nature. Feedback control system with its closed-loop structure is the essence of self-regulation for maintaining the stability of the system and/or securing its survival.

THE DOMAIN OF MANAGEMENT ACCOUNTING AND THE RELEVANCE OF CYBERNETICS

Management accounting is the application of appropriate techniques and concepts in processing the historical and projected economic data of an entity to assist management in establishing plans for reasonable economic objectives and in making of rational decisions with a view toward achieving these objectives.[27]

Although thirteen years old, the AAA definition appears to reflect the current status of management accounting.[28] In fact, this view of the current status of management accounting reflects only what is on the surface rather than what is really management accounting at the present time or going to be in the future.

One of the most basic influences on management accounting -- besides behavior, quantitative, and computer influences-- is the system and cybernetic philosophy. This philosophy made a more holistic view palatable, and induced management accountants to look beyond the confines of traditional cost accounting framework. Managementsaccountants began to realize that such notions as cost, efficiency, improvement, and so forth, can be defined and measured correctly only when comprehending the norms and goals of the larger social system in which management and its accounting frame is embodied.[29]

The impact of system philosophy is by no means limited to the extension of management accounting techniques to non-profit, government, and other nonbusiness institutions. Apart from the broadening of its boundaries, management accounting became deeper in the sense of exploring the layers of the hierarchy of systems in which it found itself embodied.[30] This philosophy also convinced some of us that management accounting needs a great deal more methodological exploration before we can expect to explain scientifically why we do what we do in such areas as technology, business, and politics.[31]

A system view for management accounting is able to incorporate experience, intuition, and judgements with scientific rationality in a meaningful framework. System theory and its methodology and philosophy are the most appropriate

frame of analysis for management accounting, and, with this frame, we may be able to achieve a unified theory for management accounting.

Management accounting as an applied and purpose-oriented subsystem has been influenced by the concepts and principles of cybernetics. Given that the core of management accounting is information to be communicated for planning and control, cybernetics is the most perfect place to start with in order to restructure and build the discipline of management accounting as an integrated, unified frame of reference capable of facing the challenge of the future.

Management accounting system is best to be viewed as a cybernetics system. It possesses all the characteristics of the cybernetics system.

Management accounting system is exceedingly complex since it is highly interconnected with most, if not all, the other systems within the organization and outside which influence the organization's operations. It is also complex since its components include behavioral variables as well as structural variables. One of the most important prerequisites for a successful management accounting is to understand how people behave and act with regard to alternative plans, standards, and forms and contents of reports. If there is no other reason for complexity, the human factor involved in processing information for planning and

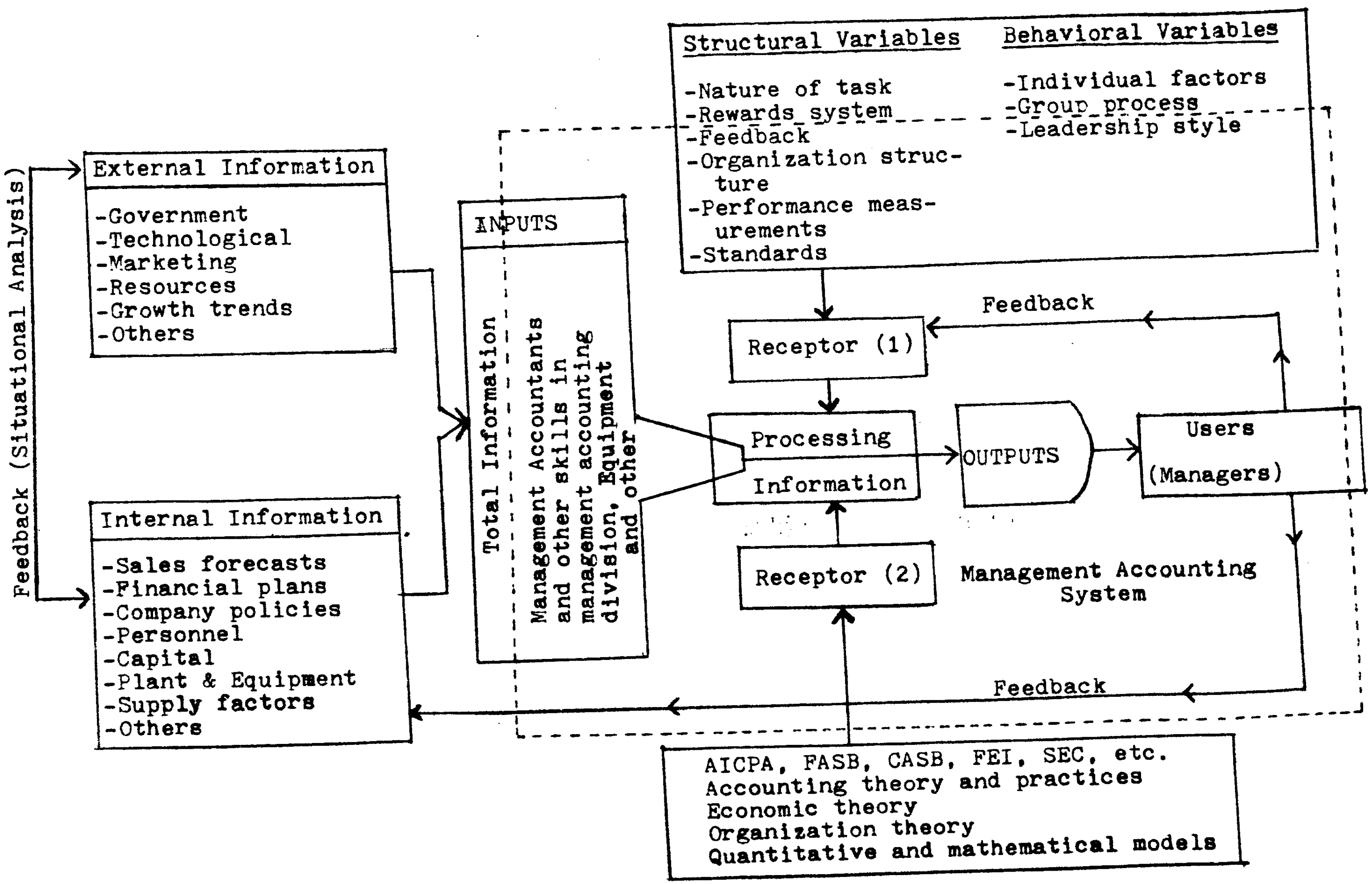
control is sufficient to make the behavior of management accounting systems very complex.

With respect to the probabilism as the second characteristic of cybernetics systems. Management accounting deals with organizations which by nature possess many multiple states of nature. For management accounting to cope with these multiple states of nature, different alternative actions should be built in it (application of the law of requisite variety). The impact of processing information on other subsystems in the organization (individual, groups) and on the environment is so intricate and dynamic, and a function of many other factors such that it is impossible to define them in detail.

With respect to "self-regulation as the third characteristic of cybernetics systems, the management accounting system focuses on designing, operating, and interpreting various levels of closed feedback loops through its internal system of feedback, which includes various control variables to self-regulate the system. On the other hand, management accounting system is an important part of the "implicit controller" at the higher level of organization hierarchy.

The potential value of cybernetics principles, concepts, and philosophy in the area of management accounting will be discussed in the next section through examining some of the cybernetics fundamentals with its applications and

Figure (3) A Cybernetic System for Management Accounting



values in enhancing the effectiveness of management accounting.

Before I leave this theoretical section, I would like to present my Viewpoint of management accounting as a subsystem within the context of an organization.

Figure (3) depicts management accounting as a cybernetic system. The resources (components) of management accounting system are:

(a) Inputs which include data and information from different sources--internal and external, human verbal material, documentary written material or based on perception. In addition to that, inputs include management accountants, other skilled workers who assist them, equipment, and other materials. We can see that some of these inputs do not need transformation. So, the distinction between inputs and processing is not sharp enough. Also, some of these inputs come from other systems.

(b) Processing or transformation is the function by which management accounting converts these inputs into output. Such processings are gathering, classifying, reclassifying, storing, recalling, and recombining the data and information. Processings also include forming judgement in forms of recommendation to management to initiate actions.

(c) Outputs include reporting, analyzing, evaluating, budget documentation, performance evaluation reports, special reports, and so on.

(d) Feedback loops are many:

1. The feedback loop between the internal and external information is in the mode of positive feedback where it is used in the stage of situational analysis (strategic planning) in order to match the internal capability of the organization and its environment. In the long-run, the survival of the organization is a function of this loop.

2. The feedback loop between the users and the management accounting receptor (1) captures the user's reaction to the reports provided by management accounting. It also captures the criteria established by users or by the specification of the decision's model. Along with the impact of the structural and behavioral variables (a small number of them could be influenced by management accounting system itself) and through receptor (1), processing information is adjusted and modified to meet a specific circumstance.

3. The feedback loop between users (managers) and

the internal information carries the actions taken by management based on management accounting reports (sometimes these actions facilitated by the management accounting system itself) which revise or update this information for the current or the subsequent periods.

(e) The environment surrounding the management accounting system also is incorporated in the model. Structural variables such as nature of tasks, reward system, organization structure, performance measurement, and standards; and behavioral variables such as individual factors, group process, and leadership style influence management accounting system.[32] However, in the long-run some of these are influenced by the performance of management accounting system (i.e. reward system, management style). Other types of environment such as FASB, CASB, FEI, federal government, SEC; accounting, economic, organization theories and practices influence the structure, performance, and the behavior of the management accounting system.[33]

Looking at management accounting system represented by a model like this will increase its effectiveness in the area of communications, planning, and control.

APPLICATION OF CYBERNETIC TOOLS TO MANAGEMENT ACCOUNTING

In this section, I will discuss some of the analytical tools of cybernetics and relate them to management accounting.

FEEDBACK SYSTEM

The idea of feedback dates back at least 2000 years. Otto Mayr in his book, "The Origins of Feedback Control," traces the evolution of the concept of feedback through three separate ancestral lines: the water clock, the thermostat, and mechanisms for controlling windmills.[34]

Feedback is defined as "the transmission of a signal from a later to an earlier stage,"[35] which acts as a regulator, a stabilizer or a stimulator. It is the essence of the control function on one hand, and on the other hand it is a step in the learning cycle, and needed by management to monitor how effective it is.

The feedback line going from the output of the system back to its input simplifies the three subsystems of the feedback system. Figure (4) depicts a feedback system and its components. As we can see, each feedback loop is comprised of:

(a) Sensor or detector subsystem that senses and

detects the central object i.e. measuring the output of the system or sensing the environment in order for the system to adapt itself and cope with its environment.

The sensor or detector sybsystem is a very critical element in the control system in any organization. One of the problems in most control systems is the weakness of this subsystem. This weakness may be in terms of frequency, capacity, efficiency, accuracy, and/or the cost of the sensor. The output of the sensor is the input to the comparator.

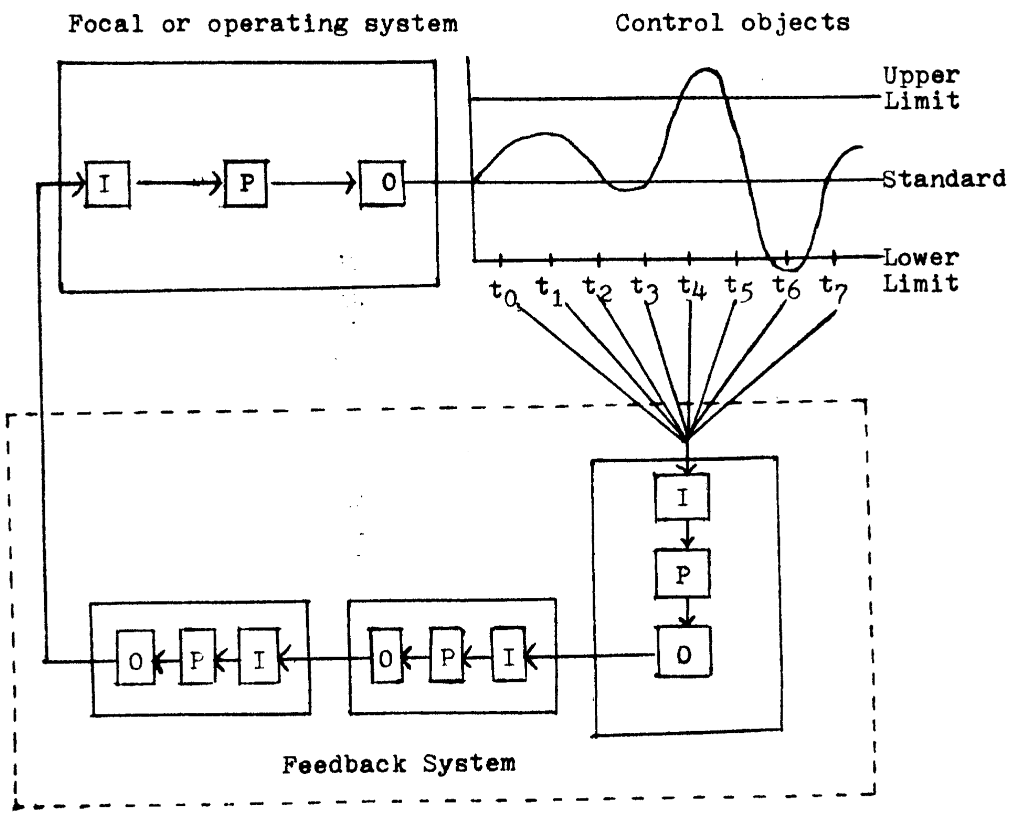
(b) Comparator subsystem which compares the actual result (the level of control object) against the desired standard or norm. Its output goes to the activator as input.

(c) Activator subsystem which is a true decision-maker that interprets the magnitude of the error (deviations), and decides whether the goals should be revised or the designed characteristics of the system should be altered, and finally commands the corrective action.

It is very important in most control systems since sometimes it can only be done by humans. It evaluates alternative courses of actions, especially

the benefits of bringing the system in control vs. the cost of investigation and correction. In other words, as Schoderbek stated, it examines the effectiveness of the other subsystem of the feedback, the feasibility of the goal being pursued, and the efficiency of the process.

Figure (4)



Adapted from: Charles G. Schoderbeck et al., op. cit., p. 94.

Jay Forrester in his book "Industrial Dynamics" characterizes feedback systems by four quantifiable dimensions: order, direction, nonlinearity, and loop multiplicity.[36]

Direction of Feedback:

A. Positive Feedback: Most of the people think of feedback in a negative sense. However, positive feedback is very important as well. It is "a deviation-amplifying rather than deviation-counteracting."[37] Positive feedback looks for a better state or level of a system behavior; it exhibits "ultra-equilibrium" state.

In social systems such as organization, positive feedback is termed "good news." Retained earnings, strategic planning, marketing function, research and development involve positive feedback loops. It is the appropriate way to control "growth" and discover what is called in marketing literature "opportunity window"[38] in order to prevent what is called in management literature "bumping into the ceiling"[39] which warns against the unhealthy side effects of the growth.

B. Negative Feedback: The dominant mode of the feedback, and it has been given almost all the attention. It is "a control-maintaining or deviation-counteracting process--it's a goal seeking--its action tends to return the system back toward its equilibrium."[40]

As Beer mentioned in illustrating the concept of

self-regulation that the act of going out of control brings back the system to its state of equilibrium which refers to the intrinsic control "error-controlled negative feedback principle."[41]

Accounting department and quality control division are examples of negative feedback devices.

C. Oscillations in Feedback Systems (Magnitude of Feedback): The magnitude of the feedback depends on the goal of the feedback system. Oscillation is inherent in all feedback systems, and we may have the following types of oscillations.

1. Stable Oscillations, which results when the feedback signal is opposite in phase to the disturbance of a system and calls for corrective action equal in amplitude. See Figure (5)a.

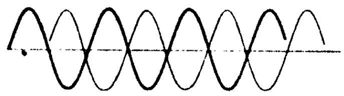
2. Oscillation is damped and may be made to disappear when the feedback is less than the variations and thus eliminates the original disturbance. See Figure (5)b.

3. Unstable Oscillation is caused by a feedback signal that induces corrective action greater than the error and thus amplifies the original disturbance. See Figure (5)c[42].

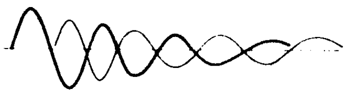
Figure (5)

Oscillations in Feedback Systems

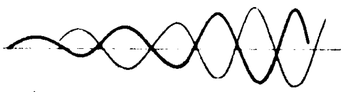
(a)



(b)



(c)



Source: **Charles G. Schoderbek,** op. cit., p. 99.

Order of Feedback:

There are three types of order of feedback systems, and it is very important to distinguish between them.

A. First-Order Feedback Systems (Automatic Goal Attainment):

All closed loop systems are sometimes referred to as first-order feedback systems or automatic goal attainment.

As we can see from Figure (6), its purpose is to maintain the system at the desired level of equilibrium regardless of changes in its environment. The goal is predetermined by a higher hierarchy and the only course of action available to this system is to adjust inputs in order to attain the desired goal. The thermostat

in the heat system or the foreman in the production shop system is an example of this type of system.

We can also see that this type of system has no memory, nor alternative courses of action; and no interaction with its environment.

Figure (6)

Automatic Goal Maintaining

First-Order Feedback

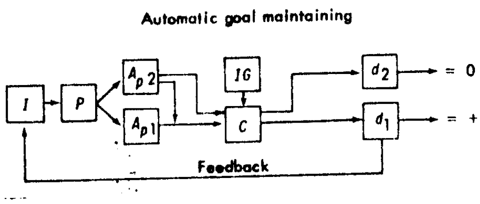


Figure (7)

Automatic Goal Changing

Second-Order Feedback

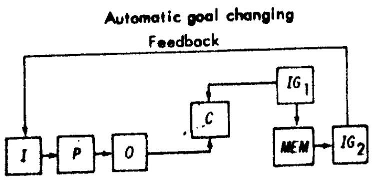
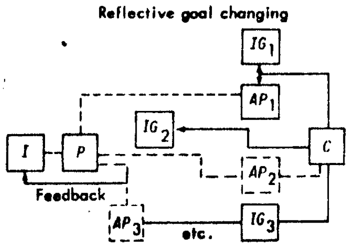


Figure (8)

Reflective Goal Changing

Third-Order Feedback



Source: Adapted from Charles G. Schoderbek, et al., op. cit., p. 266.

Legend: I = Input, P = Process, O = Output, FB = Feedback, IG = Intended Goal, AP = Actual Performance, C = Comparison, MEM = Memory, D = Deviation = IG-AP.

B. Second-Order Feedback System (Automatic Goal Changer):

This type of system has the ability to change its goals by changing the behavior of the system. However, this ability is limited to the set of alternative courses of action stored or reserved in its memory. The purpose of this system is to respond to changed external conditions by choosing the best alternative out of its memory for the particular set of conditions. It also chooses between minimizing deviations or changing the goal itself. Thus, the system has at least one memory and alternative course of action. It interacts

with its environment (open-loop system). See Figure (7).

Organization and higher level management (middle management) are examples of this type of system. Organizations as organic open systems possess one or more memory (i.e. personnel, staff, policies, procedures, files, etc.) which enables middle management, as an example, to initiate alternative courses of action (within a specified set of alternatives prescribed by top management) in response to changed environmental conditions. Computers also have this capability through the internal managements.

C. Third-Order Feedback System (Reflective Goal Changer): Unfortunately, little work has been done beyond the treatment of second-order feedback systems in many of the sciences.[43] It is the more sophisticated type of feedback since human beings should be involved in this system to close the loop of feedback. It does not only collect and store information in its memory, but also examines, evaluates, and updates its memory and formulates new courses of action. Thus, it possesses a consciousness for learning processes, by which it can reflect upon its past experience and decisions in order to respond to familiar and unfamiliar situations.

Third-order feedbacks are either of the anticipatory or of the informative type. Anticipatory feedback

concerns the prediction of future events or deviations by use of data of past events in which it would tend to hurry up the activity of the action-taking mechanism. Informative feedback controls the system by allowing the system to go out of control for a specific period or for a given level of magnitude.[44] See Figure (8).

Nonlinearity and Loop-Multiplicity:

Almost all of the available literature deals with linear and single-loop feedback system. In fact, nonlinearity dominates throughout the behavior of social systems, and multiple loops are needed to depict the behavior of these types of systems.

Application of Feedback to Management Accounting:

Management accountants would be the architects for the control theory application in the enterprise and would monitor its operation.[45]

At lower level of organization, which is described as first-order feedback systems, management accountant is the designer of the "implicit controller" by establishing points of control, allowable limits, exception reports, and provisions for initiating actions. This is what is called programmed decisions--in broad sense, decision for planning or controlling--where the feedback, mostly mechanical and self-regulation, is inherent and built in the system itself. An example of this type is inventory control feedback system.

At a higher level of organization structure where decisions are tactical, second-order feedback is the appropriate description. The role of management accountant is to participate in establishing the criteria for selecting, storing, and choosing the appropriate alternatives. The degree of automation is less than the first-order feedback system. It also ensures that all the variables needed to make control decisions are available. An example of this type is the quality control feedback control system.

At the highest level of organization structure where decisions are strategic, third-order feedback is the appropriate description. The role of management accountant is to provide top management with information needed, which stimulates their skills, past experience, and intuition to increase their capability as an implicit controller. He is trying to help top management to close the feedback loop through human being reflection. Example of this type is the efforts made by management accountant to assess top management doing control decisions pertinent to unfamiliar situations, or related to strategic subjects. He is also involved, at this stage, in controlling growth and the survival of the enterprise.

For management accounting, there are some lessons that can be learned and incorporated in any effective management accounting system:

(1) There are two vital tricks for successful control function: (a) continuous and automatic comparison, and (b) continuous and automatic feedback of correction action.[46] The unique thing here is the continuous and automatic nature of the control subsystems.

(2) Control is synonymous with communication. Control is achieved as a result of transmission of information. As Norbert Wienaer stated, "Control...is nothing but the sending of messages which effectively change the behavior of the recipient...."[47] Cybernetically, to control is to communicate and vice versa.

(3) The "servomechanisms" feature of the control systmm which results as a consequence of lesson (1) and (2). This lesson is based on Beer's observation that was mentioned before "self-regulatory."

(4) Growth and control are two sides of the same coin. A system's growth is checked and facilitated by control.[48] That means management accounting system should be designed to prevent the unfavorable effects of growth.

(5) Cybernetically, decision-making and control are similar if not identical managerial activities facilitated by management accounting. Both activities are initiated and maintained through communication, as

Schoderbek pointed out "In communicating, humans decide; in deciding, they communicate; in communicating, they control; in controlling, they communicate; .... and the cycle goes on as long as the systems remain living entities."[49]

(6) The use of feedback in a standard setting process. As an example, a study by Foran and DeCoster showed that favorable feedback about the acceptability of the performance standards will result in an increased commitment to the standards while unfavorable feedback will result in decreased commitment."[50]

Incorporating these types of thinking in management accounting system will enhance its effectiveness.

THE LAW OF REQUISITE VARIETY:

As we discussed earlier, variety is a measure of the degree of complexity inherent in the system. One way to deal with complexity in negative mode is to simplify the system by reducing the number of elements in the system, the number of the relationships among these elements, simplify the attributes of some of these elements, and/or enhance the degree of organization inherent in the system. This way is almost impossible since there are limits for simplification (abstraction) and going beyond these limits will yield misrepresentation for the real system which leads to

suboptimalization and ineffectiveness.

The other alternative for dealing with complexity in positive mode is what Ross Ashby called "The Law of of Requisite Variety." Ashby states that "only variety can destroy variety."[51] The essence of Ashby's Law is that the controller must have available to him at least as great a variety of counteractions (control measures) as the system has actions to display in order for the outcome to be certain. Ashby uses simple examples to illustrate the law.

Van Court Hare expands the concept of variety to include not only the appropriate set of counteraction but also the rate of variety, the rate of coded variety, and the ability to store, organize, integrate actions, and speed of processing information.[52]

<u>Application of The Law of Requisite Variety to Management Accounting</u>:

The law of requisite variety has universal applications and is at work in many daily situations. Many lessons could be learned from this law and applied in designing and operating management accounting system. The following are some applications or consequences of this law:

(1) It suggests that complexity may be measured by the number of countermeasures the controller must deal with in order to establish complete control over

system. The size of the organization, dollar amount, or other such parameters are irrelevant to the application of this law.

(2) In designing or reviewing the system, it makes clear to the controller "the upper limit to the amount of control that can be exerted in a given case."[53] To increase this amount of control, changes in the structure and function of the system and/or the controller by which either the variety of the system to be reduced, or the counteractions available to the controller to be increased.

(3) The complexity of management accounting system should be a one-to-one relationship to the degree of complexity inherent in the system.

(4) In designing the system, it is essential to insure that "the capacity of the channel in bits per unit time must be at least as great as the entropy of the source if messages are to be transmitted without error, assuming the absence of noise."[54]

(5) How much data and information need to be gathered, stored, and processed could be answered by the use of this law.

Given that the solution to the variety problem best be handled in positive mode (increase the variety available to management), management accounting needs

"more descriptive-simulative modeling of the forces at work in performance-control systems---and, the exploration of complementarities among competing theories."[55] This will enable management to gain greater leverage on the control of its operations.

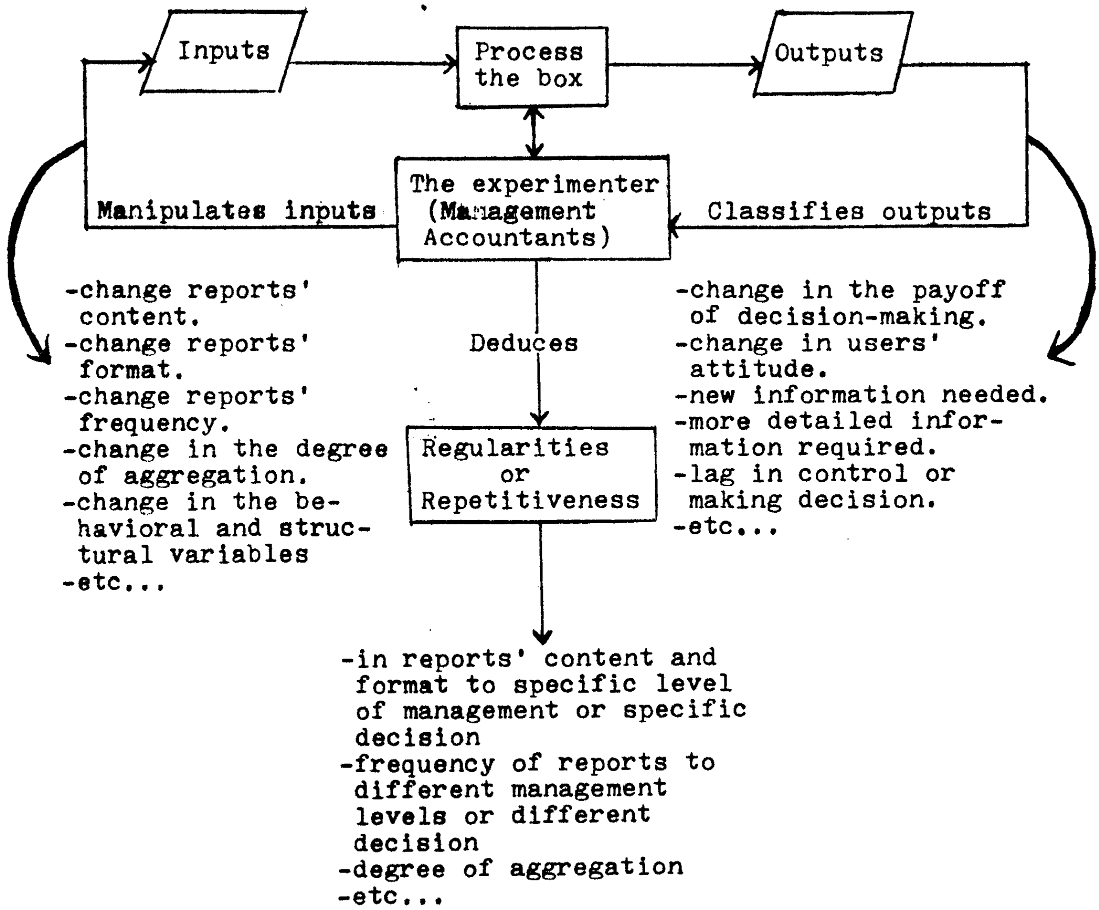
BLACK BOX:

One of the higher order simplification techniques in dealing with complexity is the "black box" technique as an analytical tool in a cybernetics system.

The theory of the black box has been dominated by electrical engineers; however, it found a wide range of applications in other disciplines. It is simply the study of relations between the experimenter and the object as well as the study of what information comes from the object and how it is obtained.[56] The black box technique and its application to management accounting is illustrated in Figure (9) which involves the following sequential steps: (1) input manipulation, (2) output classification, and (3) many-to-one transformations.

Figure (9)

The Black Box Technique



Black box technique is used when the transformation function in any system is unknown to the designer. The

operation of the black box involves manipulating (changes the magnitude, pattern, behavior, etc.) inputs of the system and then observing consequent changes in the composition of the outputs. Based on regularity or repetitiveness (similarities) as Ashby pointed out[57] or based on recognizing redundancy as Simon pointed out[58]; the experimenter classified the outputs. Repeating the loop sufficient times, the experimenter can deduce a "many-to-one" transformation and will be able to reduce the variety of the system and gain greater leverage on controlling the system.

<u>Application of Black Box To Management Accounting</u>:

The black box technique guards against the tendency of the designer or controller to oversimplify a complex system by eliminating some of its elements, reducing some of its relationships, or by breaking it into smaller parts.

As Ashby states "if a system is too complex to be understood, it may nevertheless still be controllable. For to achieve this, all that the controller wants to find is some action that gives an acceptable result; he is concerned only with what happens, not with why it happens."[59] The controller, in other words, "ultimately may think of a system as a set of 'If-Then' combinations and their corresponding outcomes."[60]

Management accountant may not know the decision criteria, set of information, and users' models required

in a specific user or a specific decision. In this case, black box technique offers a potential value in determining these unknown parameters.

Figure (9) shows how management accountant uses the black box technique in manipulating inputs (i.e. changes in the content, format, frequency of his reports to managers in different and similar situations) and classifying the output (i.e. managers' behavior and attitudes, decisions' payoff, new requirements, etc...) on the basis of regularity, repetitiveness, or redundancy. Repeating this process, management accountant can formulate appropriate parameters (i.e. criteria, information set, frequency, decision model, etc...) for a specific manager or a group and for a specific decision or a class of decisions.

ISOMORPHISM:

The basic approach of cybernetics and management science is to develop a model of the problem as we face it; the model is isomorphic (or homomorphic) with the actual problem complex, so that a solution obtained for the problem can be translated into the solution of the real-life problem.[61] The similarity of the structural and the operational characteristics between the real problem and the abstracted model or other system enables us to investigate and to predict properties of the real problem.

There are two types of isomorphism. First, strict isomorphism where two systems are isomorphic with respect to all elements and characteristics (properties). Optimal models correspond point for point with the object modeled (one-to-one correspondence). Second, restricted isomorphism where two systems are isomorphic with respect to a few desired properties (elements and characteristics).[62]

Strict isomorphism is not feasible or even required for most of the problems in application; what is needed is restricted isomorphism in few properties which satisfy the objective of the investigator.

Isomorphism is based on the idea of GST which refers to the application of certain laws across a number of different disciplines (i.e. entropy law. exponential law).

Application of Isomorphism To Management Accounting:

Potential values could be gained in the area of management accounting theory and practice by applying the concept of isomorphism.

(1) The concept of isomorphism is an invitation for the management accountant to look around in other disciplines for potential methods, techniques, theories, or models that could be applied in management accounting. In recent years, management accounting has been borrowing many methods, techniques, theories, and models from other disciplines, especially psychology, management science,

economics, etc. However, most of them are of limited usefulness because of the lack of guidance or operational criteria for application (i.e. expectancy theory, information evaluation, human information processing).

(2) The management accounting should recognize the degree of isomorphism between the model proposed to solve the problem and the real-life problem. One way is to present to users (managers) explicit statements about the assumption underlying the model and the effect of relaxing each of these assumptions.

(3) The management accounting should not assume the system to be absolutely unchanging. The solution to a problem today is not the same solution to the same problem in future.

Since most of real-life problems are dynamic in nature; hence, the current model may misrepresent the problem in the future. Therefore, the management accountant should continuously retest the models he uses.

(4) The management accounting must realize that the problem which has been formulated and constructed on paper is not the real problem. He also must insure that the decision maker understands that the paper solution hopefully will be a surrogate to the solution of the real-life problem.

(5) The management accounting must make explicit to the users the factors or variables which are not incorporated in the model (i.e. qualitative variables) and guard

against thinking in terms of optimal solutions.

The foregoing discussion pointed out to great lessons and potential values of the application of isomorphic concept and its consequences in the area of management accounting.

CONCLUSION

Management accounting is viewed as an open subsystem in the context of a larger system--the organization as a whole. Management accounting is a very complex system since it interacts with its environment. It is also probabilistic in nature since this interaction may take different states of nature.

The paper discusses the fundamentals of the science of cybernetics and the domain of management accounting. The paper concludes that for if cybernetics is the science of communication and control, and if the subject matter of management accounting might be described as the dissemination of information to assist management in doing its function, there ought to be a meaningful application of the fundamental cybernetics to the domain of management accounting.

The paper also presents a cybernetics model for management accounting system which depicts the components of management accounting system, the interaction of this system with its environment, and the feedback processes within the subsystem and with others. The model is of potential value

as a way to understand the behavior of management accounting system in the context of the general system theory. The paper concludes that general system theory and cybernetics influence management accounting theory and practice. It further concludes that the best approach to start with in restructuring and building a unified management accounting theory is cybernetics concepts, methodology and analytical tools.

The last section of this paper is devoted to the discusion of potential application of cybernetics analytical tools in management accounting. It discusses the concept of feedback, its application in management accounting, and the role of management accountant in designing and monitoring the feedback systems in the organization. The "Law of Requisite Variety" is discussed as a cybernetic tool which provides guidance to management accountants in possessing a greater leverage over the system. The "Theory of Black Box" is also discussed as a cybernetic tool which permits the management accountant to reduce the variety and complexity of the system, to understand the behavior of the system, and to determine the pattern of the unknown decision-making process's parameters. Finally, the "Isomorphism" is discussed as a cybernetic tool which guides the management accountant in building models, recognizing the assumptions and limitations of these models, recognizing the factors not included in these models

which affect the outcomes, and in communicating this information to the users (managers).

In summary, I found that area of cybernetics and general system theory is very promising and provides many useful ideas in developing the theory and practice of management accounting and unified the competing and fragmented theories which are currently in use.

FOOTNOTES

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